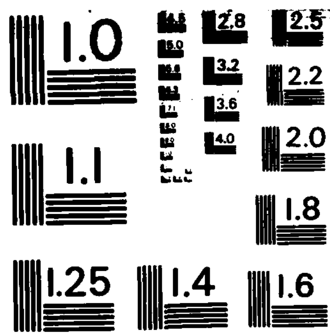
AD-A139 849 DIMENSIONALITY SCORING AND RELATED PROBLEMS IN ADAPTIVE 1/1
TESTING(U) ILLINOIS UNIV AT URBANA COMPUTER-BASED
EDUCATION RESEARCH LAB.. J M EDDINS ET AL. JAN 84
UNCLASSIFIED CERL-FR-83-5-ONR N00014-79-C-0752 F/G 5/10 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

Computer-based Education Research Laboratory **CERL**

FINAL REPORT:

DIMENSIONALITY, SCORING AND RELATED PROBLEMS IN ADAPTIVE TESTING

PART 1

AD A139849

JOHN M. EDDINS

Computer-based Education Research Laboratory
University of Illinois at Urbana-Champaign

Principal Investigators
KIKUMI and MAURICE TATSUOKA

This research was sponsored by the Personnel and Training
Research Program, Psychological Science Division, Office
of Naval Research, under Contract No. N00014-79-C-0752.
Contract Authority Identification Number NR 150-415.

FINAL REPORT 83-5-ONR JANUARY 1984

University of Illinois at Urbana-Champaign

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Final Report 83-5-ONR	2. GOVT ACCESSION NO. AD-A139 849	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Final Report of the Project on "Dimensionality, Scoring, and Related Problems in ~~Individual-ized Measurement~~ ADAPTIVE TESTING, Part I,"		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John M. Eddins		8. CONTRACT OR GRANT NUMBER(s) N00014-79-C-0752
9. PERFORMING ORGANIZATION NAME AND ADDRESS Computer-based Ed. Res. Lab. 103 S. Mathews St. - U of Illinois Urbana, IL 61801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61153N: RR 042-04 NR 154-445
11. CONTROLLING OFFICE NAME AND ADDRESS Personnel and Training Research Programs Office of Naval Research (Code 458) 800 N. Qunicy St., Arlington VA 22217		12. REPORT DATE ~~May 1983~~ JANUARY 1984
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Misconceptions, item response theory, dimensionaltiy, error analysis, rule space, signed-number arithmetic, error detection, error classification, norm conformity index, individualized consistency index, extended caution index

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Abstract

Major efforts of the project fall into four categories:

1) Investigations were performed on the relationship between the dimensionality of a dataset and its underlying cognitive processes. The datasets represent the computational arithmetic domains of addition and subtraction of signed numbers and fractions. Error diagnostic computer programs for these computational skills written on the PLATO[R] system were used for examining each student's procedural rule. Various analyses imply that the systematic application of erroneous rules by many students causes multidimensionality of the data.

2) Two approaches for diagnosing erroneous rules of operation were developed; an "error vector" system for constructing error diagnostic programs for signed-number arithmetic and fraction addition problems, and a series of logical statements for constructing diagnostic programs for fraction problems. A series of experimental data collected between 1979-1982 revealed that the rate of diagnosing erroneous rules by these deterministic approaches becomes very low (about 50%) when learning is most active. Hence, it is impossible to help students with prescriptive information from these error diagnostic systems. Moreover, developing such computer programs in general areas will be painstaking and time-consuming.

3) To circumvent the problems encountered in the construction of error diagnostic programs, two indices based on deterministic Guttman theory were formed and used to detect aberrant response patterns. The first of these indices was useful in categorizing erroneous rules into serious or less-serious errors. The second index proved to be very powerful for detecting erroneous rules resulting from the students' misconceptions. In several different datasets of arithmetic computations, the detection rates were always higher than 95% of the erroneous rules which had been diagnosed separately by the error vector system.

4) The necessity for dealing quantitatively with variations in errors and changing rules of operation led to the investigation of probabalistic models for error diagnosis based on item response theory. A group of extended caution indices was formulated. These indices have a prominent mathematical feature and some functional similarities to both of the other indices; however, used traditionally, their detection rate for some of the most frequent erroneous rules is unexpectedly low. As an alternative approach, the concept of "rule space" was developed. All responses, both correct and erroneous, are decomposed into components, which are mapped into a vector space spanned by the true scores and one of the standardized extended caution indices (ECI4z). A pattern classification technique is used to separate each rule from its neighboring points in the rule space. Since the ECI4z is a continuous function, those points which plot close to a rule represent responses yielded by "slips" or random errors, or by imperfect applications of the rule.

DIMENSIONALITY

One of the first goals of the project was to address the problem of multidimensionality of achievement test data. Latent trait theory provides a potentially powerful tool for locating a person's ability or achievement level within a hierarchical set of test items; however, latent trait models require that test data be unidimensional (i.e., that they measure a single trait). On the other hand, achievement test data usually are multidimensional, so that difficulties were anticipated in the application of latent trait theory to the diagnosis of student errors on achievement tests.

Several datasets were collected from seventh and eighth grade students taking computerized tests on the PLATO® system during 1979 - 1980, while five datasets were simulated on the PLATO® computer. All datasets were based on test results within the domain of signed-number arithmetic. Tatsuoka, et al. (Tatsuoka & Baillie, 1982a; Tatsuoka, et al., 1982) developed "SIGNBUG", a set of computer programs on the PLATO® system which analyze each student's procedural rules for solving signed-number arithmetic problems.

These data were used in several experiments which investigated the relationship between the dimensionality of a dataset and the cognitive processes which led to the student's solution of the problems. One study examined the dimensionality of an achievement test across different learning stages under two different instructional methods (Tatsuoka, 1981). This study demonstrated that different instructional methods affect the dimensionality of test scores to a large extent. The results also indicate that in the early stages of learning, students tend to use their rules of operation inconsistently during the test. This causes a

clear violation of the local independence assumption, which is essential to latent trait theory.

A second study compared the dimensionality of achievement test scores based only on correct answers, to scores based on whether the student used the correct algorithm (Birenbaum & Tatsuoka, 1980, 1983). Results indicate that in achievement data based on a specific arithmetic problem-solving domain, the factorial structure of the data is strongly affected when a variety of different algorithms underlie the student responses, with a resulting increase in the dimensionality of the data. The fact that students may get right answers by following a wrong rule is reflected in the psychometric properties of the test. When the conventional scoring system is used, it results in negative correlations among some items, and increased dimensionality; when the scoring system takes into consideration the thought processes of the student, there is a reduction in dimensionality and considerably higher correlations among the tasks, without changing their mean values.

The simulated data referred to above were used as a means to control the number of algorithms underlying the responses, in order to study the effect on dimensionality of the test data when the number of algorithms increases (Birenbaum & Tatsuoka, 1982). This simulation was meant to describe a situation in which 25% of the subjects knew nothing about the topic being tested, merely guessing randomly for the answers, while another 25% had mastered the tasks and answered all of the items correctly. The remaining half of the subjects were presumed to have mastered incorrect rules. The number of incorrect algorithms was increased with each successive dataset; one in the first, two in the

second, up to five in the fifth, distributed in each set in equal proportions. In order to make the effect of the algorithms clearer, a hypothetical situation was simulated in which 75% of the responses were consistent, i.e., each subject used the same rule consistently throughout the test. A principal components analysis of these data demonstrated that an increase in the number of wrong algorithms results in a decrease in both the reliability coefficients and in the amount of variance accounted for by the first factor. A similar analysis of real data collected before and after instruction, as well as for two kinds of instruction, indicated less heterogeneity of the underlying algorithms (i.e., fewer wrong rules) after instruction than before, regardless of the kind of instruction.

Two mathematical methods for extracting unidimensional subsets from multidimensional datasets were investigated. An algorithm based on graph theory efficiently extracted nonredundant chains of items using a series of matrix manipulations performed on the dominance matrix (Yamamoto & Wise, 1980), and an order-analysis procedure was used successfully to isolate uni-dimensional item subsets in both real and simulated data (Wise, 1981).

ERROR DIAGNOSIS

Two methods were developed for diagnosing erroneous rules of operation. In the first of these, a system of binary error vectors was generated from item responses (Tatsuoka, et al., 1980). Operations in signed number addition were decomposed into sign and absolute value components, and each component was represented by a vector of binary numbers accounting for all

possible operations for doing the problem. By a process of elementwise multiplication of the set of error vectors, a particular wrong rule can be determined uniquely, provided the student consistently uses that rule.

The second method for diagnosing erroneous rules consisted in the derivation of a series of logical statements to be used for constructing error-diagnostic programs. Klein, et al. (1981),) described and illustrated a procedure for constructing error-diagnostic items for addition and subtraction of fractions, based on a procedural network. This approach is too complex to be practical, and the need for defining a hierarchy of item difficulty was recognized.

Tatsuoka and Tatsuoka (1981b) described a system of order analysis that was developed by Takeya (1981), called item relation structure analysis, and used it for examining the structural relations among a set of 24 items in addition and subtraction of fractions. The goal was to devise a technique for investigating the item structure with respect to the roles of each item in determining the student's misconceptions. Results were inconclusive, though promising, and the need for further study was indicated.

Standiford, et al. (1982), described a procedural network for solving problems in decimal fraction addition and subtraction, and compared the item dominance predicted from this network with that predicted from the item relations structure analysis model. In general, the latter model confirmed item dominance patterns predicted by the former.

Chevalaz and Tatsuoka (1983) described and compared two order analytic techniques for analyzing the structure of a test. Ordering theory of Krus and Bart (1974), and the item relation structure analysis method proposed by Tatsuoka and Tatsuoka (1981b) were used to extract the hierarchical

item structure from three datasets. It was found that the Krus and Bart procedure more adequately represented the complex interrelationships among test data, but that use of the item relation structure analysis appears to be more appropriate when the data contains many errors.

As part of the effort to identify and catalog specific erroneous rules, Shaw, et al. (1982), analyzed results of a written test in fraction addition, and interviewed many of the students. Their report describes the test performance of 26 students who displayed a variety of erroneous rules. The cases were selected for their potential usefulness in designing and implementing an error-diagnostic testing system and in designing appropriate remediation.

Tatsuoka (1981) attempted to quantify the relative seriousness of errors in signed number addition problems. All component procedures for carrying out the addition problems properly were expressed by a hierarchical tree. Then, each erroneous rule was characterized by assigning two quantities, representing what and how many steps were followed to produce the responses. If a rule were the result of a misconception at an earlier level in the network, then it was more likely committed by students in the early stage of learning, or by lower ability students. For students nearing mastery, any erroneous rules would be due to mistakes from the latter part of the procedural network. A procedural steps conformity index was designed to express quantitatively both single and compound error sources. The need for further work in generalizing these procedures was recognized.

Using the same error classification system, Tatsuoka (1984) divided 27 erroneous rules of signed-number addition problems into two groups,

non-serious (A) and serious (B) error types, in order to investigate changes over time in their rate of incidence. Forty-five subjects from junior high school took a test in signed-number addition, which was administered six times at various stages of instruction over a period of a year and a half. Those students whose verbal ability as measured by the Stanford Verbal Test fell in the top 16% also were identified. Results showed (1) use of the right rule decreased over the first three tests, then increased dramatically; (2) use of A-type rules did not change much, while use of B-type rules decreased slowly over time; (3) on the second test students with high verbal ability used A-type rules much more than the more serious B-type, but the reverse was true for the other students. The latter finding suggests that students with high verbal ability may be less likely to adopt the more serious error types in the early stages of learning.

Tatsuoka and Birenbaum (1981) reported the observed effects on test performance resulting from differences in instructional backgrounds. An adaptive diagnostic test was used as an integral part of an instructional program in signed-number arithmetic on the PLATO^R system. The testing procedure worked well for most examinees, but not for those who had been exposed to a different conceptual framework prior to the PLATO^R instruction. Differences in prior and subsequent instructional methods affected the learning of more advanced materials and produced lower achievement scores on the posttest given at the end of the program. These results present a serious problem when students are to be routed to an instructional level based only on performance on a diagnostic test. It is important to examine the conceptual basis for both stages of instruction and to route each examinee accordingly.

The two methods for diagnosing errors referred to above are both deterministic; therefore, their rate of diagnosis diminishes if students apply their rules inconsistently. Analysis of data gathered during 1979-1980 (Birenbaum & Tatsuoka, 1981; Tatsuoka, 1983a) confirmed that (1) students tend to change their rules of operation most during the early stages of learning, and (2) the rate of diagnosis decreases accordingly, to as low as 50%. Since this is precisely the learning stage when diagnosis is most needed, it is impossible to help students with prescriptive information from these error-diagnostic systems. Furthermore, the creation of computer programs for error vector systems and process networks is too complex and time-consuming for general applications.

NORM CONFORMITY AND INDIVIDUAL CONSISTENCY INDICES

Since the usefulness of the error diagnostic programs is seriously limited when students change their rules of operation, a method for detecting such changes seemed useful. Accordingly, two indices were developed for measuring the degree of conformity or consistency of an individual examinee's response pattern on a set of items (Tatsuoka & Tatsuoka, 1980; 1981a; 1982a; 1983). The first, called the norm conformity index (NCI), measures the proximity of the pattern to a baseline pattern in which all 0's precede all 1's when the items are arranged in some prescribed order. The second, called the individual consistency index (ICI), measures the extent to which an individual's response pattern remains invariant when he or she responds to several waves of parallel items. Both of these indices were developed originally as potential tools

for assisting in the extraction of subsamples of examinees for whom the data are uni-dimensional or nearly so.

The NCI is a sort of backward extension to the individual level of one of Cliff's group consistency indices. Its calculation requires that the test items be rearranged in the order of difficulty for some particular group. The NCI turned out not to be very useful for the originally intended purpose of extracting unidimensional subgroups. Rather, it was found to be more useful in highlighting the different response patterns that are typical of individuals with different instructional backgrounds, and in categorizing erroneous rules by degree of seriousness.

The ICI depends on the task difficulties as determined by an individual student's state of knowledge. Its definition calls for the existence of two or more parallel subtests. Calculation of the ICI is the same as that for the NCI, except that the items are arranged in the order of difficulty of the skill types for the particular individual instead of the order of difficulty for a group. The unique feature of the ICl is that its values are individually oriented and free from group dependence.

The ICI was found to be quite useful for identifying individuals who could be removed from a sample to improve the approximation to unidimensionality exhibited by the data matrix of the remaining group. The ICI value is large when an individual responds to similar items in the same way. A small ICI value indicates uncertain or random responses. A combination of high ICI and low total score indicates consistent errors, while a combination of low ICI and low total score suggests that the student does not have a clear method for proceeding and is answering at random or by trial and error.

Application of the ICI, together with the total scores, to several of the signed number arithmetic datasets detected most (over 95%) of the erroneous rules which had been detected separately by the error vector diagnostic system.

Although the ICI is useful in detecting aberrant response patterns resulting from the use of wrong algorithms, it requires repeated measures in a test. Therefore, the index is not applicable to many commercial achievement tests or to criterion referenced tests designed to measure the outcome of treatments in a wide range of content areas. However, when tests are aimed at assessing the progress of a student's learning and used as an integral part of instruction, the information obtained from the ICI will be useful for assessing how well the student understands the subject.

EXTENDED CAUTION INDICES AND RULE SPACE

The necessity for dealing quantitatively with variations in errors and changing rules of operation led to the investigation of probabalistic models for error diagnosis based on item response theory. Indices of the degree to which an individual's pattern of responses is unusual were classified into two general types: (1) those that use item response theory and (2) those that rely on observed item responses and standard summary statistics based on those responses. Tatsuoka and Linn (1981, 1983) demonstrated a link between these two approaches by showing a correspondence between the S-P curve theory developed by Sato, and test response curves and group response curves developed from item response theory. Furthermore, the caution index defined in Sato's S-P curve theory, which is based on

a comparison of observed item responses to group responses, was extended to theory-based estimates of person and group response probabilities. That is, S-P curve theory and the caution index, which originally were developed within a discrete domain of 0-1 scoring, were extended to a more general case of probabilities.

Five extended caution indices were defined, designated respectively the ECI1, ECI2, ECI3, ECI4, and ECI5. These indices are linear transformations of the covariance of a person's response pattern with one of two theoretical curves computed using item response theory (i.e., the group response curve for the ECI1, ECI2 and ECI3, or the person response curve for the ECI4 and ECI5).

The ECI4 is similar to the individual consistency index, or ICI (see above). The ICI was shown to be useful in detecting a variety of erroneous rules of operation with signed-number addition and subtraction problems, but its application is limited because it requires repeated measures within a test. The ECI4 not only avoids the repeated measures limitation but it also is effective for identifying persons who consistently use an erroneous rule in answering signed-number arithmetic problems. Based on its application to a set of achievement test data, the ECI4 distinguishes persons who are consistently using erroneous rules from those who are not, provided that these erroneous rules are not popular in the data used for estimating item and person parameters. Therefore, selection of the correct data set for estimating these paramaters is very important when applying these indices.

Tatsuoka and Tatsuoka (1982a) investigated the statistical properties of the ECI1, ECI2 and ECI4. They found that both the ECI1 and ECI2 have

the constant expectation of zero, regardless of the level of the person parameter θ_i, while the expectation of the ECI4 is a function of θ_i.

As was shown with data from a 40-item signed number subtraction test, the conditional variances of the three ECIs under consideration have U-shapes, with inflated values at both the extremely high and extremely low true scores and fairly constant values in between. In order to avoid this weakness, the ECI1, ECI2, and ECI4 were standardized by subtracting the conditional expectation of each ECI from the original ECI and dividing by the square root of its conditional variance (Harnisch & Tatsuoka, 1983). Goodness-of-fit tests of the standardized ECI's showed that they fit normal distributions well.

Since all of the extended caution indices are based on conditional probability of θ_i, they do not allow a fair comparison of two values if they are obtained from examinees at two different ability levels. However, since the standardized ECI's do not depend on θ_i, two standardized ECI values obtained from different θ_i values are comparable in terms of the extent of anomaly they signify.

The use of the various ECI's for detection of erroneous rules proved to be unexpectedly low in all cases (about 60%). Although the reasons for this are not entirely clear, it appears that if an otherwise normal dataset includes a considerable number of aberrant response patterns, then such patterns are no longer detectable with high probably by the traditional use of these indices. Investigation of an alternative approach therefore was necessary.

A probabalistic model was developed, called "rule space," in which all responses, both correct and erroneous, are decomposed into component

parts and mapped as points in a geometric space (Tatsuoka, 1983a, 1983b; Tatsuoka & Baillie, 1982b). Rule space is defined as the cartesian product of the estimated true scores and the values of the standardized extended caution index ECI4z (Tatsuoka & Baillie, 1982b). In other words, rule space is a geometric representation of the rules used by the student. In this space, the erroneous rules resulting from the same kind of misconception cluster closely, as was confirmed by results plotted from several datasets.

The advantage of using the standardized extended caution index ECI4z is its effectiveness for separating clusters of responses from one another. If two response patterns from the same θ level differ they will be plotted at different locations in the rule space. Furthermore, the degree of unusualness of a response is represented by its distance from the true-score axis. A cluster of response patterns consists of the response pattern yielded by some rule and its "slips," due to partially consistent application of the rule. Using pattern classification to separate the clusters in the rule space accounts for variability of errors in the model (Tatsuoka, 1982b). By calculating a set of linear classification functions of the various clusters and by setting boundaries to divide the regions, it is possible to identify the underlying misconception of a new response with some probability of error by examining in which region the new response falls. Thus, the problem of diagnosing an individual student's misconceptions has been transmuted into a classification problem. Using the probabilistic approach of rule space and pattern classification for the diagnosing of errors promises to remedy the weaknesses of deterministic methods without losing their strengths.

REFERENCES

Birenbaum, M., & Tatsuoka, K. K. The use of information from wrong responses in measuring students' achievement level (Technical Report 80-1-ONR). Urbana, Ill.: University of Illinois, February 1980.

Birenbaum, M., & Tatsuoka, K. K. The effect of different instructional methods on error types and the underlying dimensionality of the test, part I (Technical Report 81-3-ONR). Urbana, Ill.: University of Illinois, February 1981.

Birenbaum, M., & Tatsuoka, K. K. On the dimensionality of achievement test data. Journal of Educational Measurement, 1982, 19(4), 259-266.

Birenbaum, M., & Tatsuoka, K. K. The effect of a scoring system based on the algorithm underlying the students' response patterns on the dimensionality of achievement test data of the problem solving type. Journal of Educational Measurement, 1983, 20(1), 17-26.

Chevalaz, G. M., & Tatsuoka, K. K. A comparative analysis of two order analytic techniques: Assessing item hierarchies in real and simulated data (Technical Report 83-2-NIE). Urbana, Ill.: University of Illinois, April 1983.

Harnisch, D., & Tatsuoka, K. K. Comparison of appropriateness measures based on IRT. In R. K. Hambleton, (Ed.), Applications of Item Response Theory. Vancouver: Educational Research Institute of British Columbia, 1983.

Klein, M., Birenbaum, M., Standiford, S., & Tatsuoka, K. K. Logical error analysis and construction of tests to diagnose student "bugs" in addition and subtraction of fractions (Technical Report 81-6-NIE). Urbana, Ill.: University of Illinois, November 1981.

Krus, E., & Bart, W. M. An ordering theoretic method of multidimensional scaling of items. Educational and Psychological Measurement, 1974, 34, 525-535.

Shaw, D. J., Standiford, S. N., Klein, M. F., & Tatsuoka, K. K. Error analysis of fraction arithmetic -- selected case studies (Research Report 82-2-NIE). Urbana, Ill.: University of Illinois, February 1982.

Standiford, S. N., Klein, M. F., & Tatsuoka, K. K. Decimal fraction arithmetic: Logical error analysis and its validation (Research Report 82-1-NIE). Urbana, Ill.: University of Illinois, February 1982.

Takeya, M. A study on item relational structure analysis of criterion referenced tests. Unpublished Ph.D. dissertation. Tokyo, Waseda University, June 1981.

Tatsuoka, K. K. An approach to assessing the seriousness of error types and the predictability of future performance (Technical Report 81-1-ONR). Urbana, Ill.: University of Illinois, February 1981.

Tatsuoka, K. K. A latent trait model for interpreting misconceptions in procedural domains. In D. Weiss (Ed.), The 1982 proceedings of Item response Theory and Computerized Adaptive Testing Conference. Minneapolis, Minnesota, August 1982b.

Tatsuoka, K. K. Rule space: Geometric representation of misconceptions and quantitative treatment of their behavior. Paper presented at the Annual Meeting of the American Educational Researchers Association, Montreal, 1983a.

Tatsuoka, K. K. Rule space: An approach for dealing with misconceptions based on item response theory. Journal of Educational Measurement, 1983b, 20(4), 345-354.

Tatsuoka, K. K. Changes in error types over learning stages. Journal of Educational Psychology, 1984, 76(1), 120-128.

Tatsuoka, K. K., & Baillie, R. SIGNBUG: An error diagnostic computer program for signed-number arithmetic on the PLATO[R] system. Urbana, Ill.: University of Illinois, 1982a.

Tatsuoka, K. K., & Baillie, R. Rule space, the product space of two score components in signed-number subtraction: An approach to dealing with inconsistent use of erroneous rules (Research Report 82-3-ONR). Urbana, Ill.: University of Illinois, March 1982b.

Tatsuoka, K. K., & Birenbaum, M. Effects of instructional backgrounds on test performances. Journal of Computer-based Instruction, 1981, 8, 1-8.

Tatsuoka, K. K., Birenbaum, M., Tatsuoka, M. M., & Baillie, R. Psychometric approach to error analysis of response patterns of achievement tests (Technical Report 80-3-ONR). Urbana, Ill.: University of Illinois, February 1980.

Tatsuoka, K. K., & Linn, R. L. Indices for detecting unusual item response patterns in personnel testing: Links between direct and item response theory approaches (Technical Report 81-5-ONR). Urbana, Ill.: University of Illinois, August 1981.

Tatsuoka, K. K., & Linn, R. L. Indices for detecting unusual response patterns: Links between two general approaches and potential applications. Applied Psychological Measurement, 1983, 7(1), 81-96.

Tatsuoka, K. K., & Tatsuoka, M. M. Detection of aberrent response patterns and their effect on dimensionality (Technical Report 80-4-ONR). Urbana, Ill.: University of Illinois, April 1980.

Tatsuoka, K. K., & Tatsuoka, M. M. Spotting incorrect rules in signed-number arithmetic by the individual consistency index (Technical Report 81-4-ONR). Urbana, Ill.: University of Illinois, August 1981a.

Tatsuoka, K. K., & Tatsuoka, M. M. Item analysis of tests designed for diagnosing bugs: Item relational structure analysis method (Research Report 81-7-NIE). Urbana, Ill.: University of Illinois, November 1981b.

Tatsuoka, K. K., & Tatsuoka, M. M. Standardized extended caution indices and comparisons of their rule detection rates (Research Report 82-4-ONR). Urbana, Ill.: University of Illinois, March 1982a.

Tatsuoka, K. K., & Tatsuoka, M. M. Detection of aberrant response patterns and their effect on dimensionality. Journal of Educational Statistics, 1982b, 7(3), 215-231.

Tatsuoka, K. K., & Tatsuoka, M. M. Spotting erroneous rules of operation by the individual consistency index. Journal of Educational Measurement, 1983.

Wise, S. L. Some comparisons of four order-analytic methods and factor analysis for assessing dimensionality (Technical Report 81-2-ONR). Urbana, Ill.: University of Illinois, February 1981.

Yamamoto, Y., & Wise, S. L. Extracting unidimensional chains from multidimensional datasets: A graph theory approach (Technical Report 80-2-ONR). Urbana, Ill.: University of Illinois, February 1980.

Distribution List

Navy

1 Dr. Ed Aiken
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Arthur Bachrach
Environmental Stress Program Cntr.
Naval Medical Research Institute
Bethesda, MD 20014

1 Meryl Baker
NPRDC
Code P309
San Diego, CA 92152

1 Liaison Scientist
ONR, Branch Office
Box 39
FPO New York, NY 09510

1 Lt. Alexander Bory
Applied Psychology
Measurement Division
NAMRL
NAS Pensacola, FL 32508

1 Dr. Robert Breaux
NACTRAEQUIPCEN
Code N-095r
Orlando, FL 32813

1 Dr. Robert Carroll
NAVOP 115
Washington, DC 20370

1 Chief of Naval Education
Liasan Office
Air Force Human Resource Lab
Operations Training Division
Williams AFB, AZ 85224

1 Dr. Stanley Collyer
Office of Naval Technology
800 N. Quincy St.
Arlington, VA 22217

1 CDR Mike Curran
Office of Naval Research
800 N. Quincy St.
Code 270
Arlington, VA 22217

1 Dr. Tom Duffy
Navy Personnel R&D Center
San Diego, CA 92152

1 Mike Durmeyer
Instrucional Program Develoment
Building 90
NET-PDCD
Great Lakes NTC, IL 60088

1 Dr. Richard Elster
Department of Admin. Scie.
Naval Postgraduate School
Monterey, CA 93940

1 Dr. Pat Federico
Navy Personnel R&D Center
Code P13
San Diego, CA 92152

1 Dr. Cathy Fernandes
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. John Ford
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Jim Hollan
Code 14
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Ed Hutchins
Navy Peronnel R&D Center
San Diego, CA 92152

1 Dr. Norman Kerr
Chief of Naval Technical Training
Naval Air Station Memphis (75)
Millington, TN 38054

1 Dr. Peter Kincaid
Training Analysis & Eval. Group
Department of Navy
Orlando, FL 32813

1 R. W. King
Director, Naval Ed. & Training
Deparment of the Navy
Orlando, FL 32813

1 Dr. Leonard Kroeker
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. William L. Maloy (02)
Principal Civilian Advisor for
Education and Training
Naval Training Command, Code 00A
Pensacola, FL 32508

1 Dr. Kneale Marshall
Chairman, Operations Res. Dpt.
Naval Post Graduate School
Monterey, CA 93940

1 Dr. James McBride
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. William Montague
Navy Personnel R&D Center
Code P13
San Diego, CA 92152

1 Dr. William Nordbrook
1032 Fairlawn
Libertyville, IL 60048

6 Personnel & Training Research Programs
(442 PT)
Office of Naval Research
Arlington, VA 22217

1 Special Asst. for Ed &
Training (OP-01E)
Rm. 2705 Arlington Annex
Washington, DC 20370

1 Lt. Frank C. Petho, MSC, USN, Ph.D.
CNET (N-432)
NAS
Pensacola, FL 32508

1 Dr. Bernard Rimland (01C)
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Carl Ross
CNET-PDCD
Building 90
Great Lakes NTC, IL 60088

1 Dr. Worth Scanland, Director
CNET (N-5)
NAS
Pensacola, FL 32508

1 Dr. Robert Smith
ONR
OP-987H
Washington, DC 20350

1 Dr. Alfred F. Smode
Training Analysis & Ev. Grp.
(TAEG)
Dept. of the Navy
Orlando, FL 32813

1 Dr. Richard Sorensen
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Frederick Steinheiser
CNO-OP115
Navy Annex
Arlington, VA 20370

1 Brad Sympson
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Frank Vicino
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Edward Wegman
ONR (Code 411S&P)
800 N. Quincy St.
Arlington, VA 22217

1 Dr. Ronald Weitzman
Code 54 WZ
Dpt. of Admin. Sci.
U.S. Naval Postgrad. Schl.
Monterey, CA 93940

1 Dr. Douglas Wetzel
Code 12
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Martin F. Wiskoff
Navy Personnel R&D Center
San Diego, CA 92152

1 Mr. John H. Wolfe
Code P310
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Wallace Wulfeck, III
Navy Personnel R&D Center
San Diego, CA 92152

Army

1 Technical Director
Army Res. Inst.
5001 Eisenhower Ave.
Alexandria, VA 22333

1 James Baker
Army Res. Inst.
5001 Eisenhower Ave.
Alexandria, VA 22333

1 Dr. Kent Eaton
Army Research Institute
5001 Eisenhower Blvd.
Alexandria, VA 22333

1 Dr. Beatrice Farr
Army Res. Inst.
5001 Eisenhower Ave.
Alexandria, VA 22333

1 Dr. Myron Fischl
Army Res. Inst.
5001 Eisenhower Ave.
Aexandria, VA 22333
Alexandria, VA 22333

1 Dr. Milton S. Katz
Training Tech. Area
Army Res. Inst.
5001 Eisenhower Ave.
Alexandria, VA 22333

1 Dr. Harold F. O'Neil, Jr.
Army Res. Inst.
5001 Eisenhower Ave.
Alexandria, VA 22333

1 Mr. Robert Ross
Army Res. Inst.
5001 Eisenhower Ave.
Alexandria, VA 22333

1 Dr. Robert Sasmor
Army Res. Inst.
5001 Eisenhower Ave.
Alexandria, VA 22333

1 Dr. Joyce Shields
ARI
5001 Eisenhower Ave.
Alexandria, VA 22333

1 Dr. Hilda Wing
ARI
5001 Eisenhower Ave.
Alexandria, VA 22333

Air Force

1 AF Human Resources Lab.
AFHRL/MPD
Brooks AFB, TX 78235

1 Technical Documents Center
AF Human Resources Lab
WPAFB, OH 45433

1 AF Office of Sci. Res.
Life Sciences Directorate, NL
Bolling AFB
Washington DC 20332

1 Air University Libraryf
AUL/LSE 76/443
Maxwell AFB, AL 36112

1 Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

1 Mr. Raymond E. Christal
AFHRL/MOE
Brooks AFB, TX 78235

1 Dr. Alfred R. Fregly
AFOSR/NL
Bolling AFB, DC 20332

1 Dr. Genevieve Haddad
Program Manager
Life Sciences Directorate
AFOSR
Bolling AFB,
Washington, DC 20332

1 Dr. T. M. Longridge
AFHRL/OTE
Williams AFB, AZ 85224

1 Dr. Roger Pennell
AF Human Resources Lab
Lowry AFB, CA 80230

1 Dr. Malcolm Ree
AFHRL/MP
Brooks AFB, TX 78235

1 3700 TCHTW/TTGHR
2 Lt Tallarigo
Sheppard AFB, TX 76311

1 Dr. Joseph Yasatuke
AFHRL/LRT
Lowry AFB, CO 80230

Marine Corps

1 H. William Greenup
Education Advisor (E031)
Education Center, MCDEC
Quantico, VA 22134

1 Director, Off. of Manpwr Util.
HQ, Marine Corps (MPU)
BCB, Bldg. 2009
Quantico, VA 22134

1 HQ, Marine Corps
Code MPI-20
Washington, DC 20380

1 Special Ast. for Marine Corps
Code 100M
Office of Naval Research
800 N. Quincy St.
Arlington, VA 22217

1 Dr. A.L. Slafkosky
Scientific Advisor (Code RD-1)
HQ, Marine Corps
Washington, DC 20380

1 Major Frank Yohannan, USMC
Headquarter, Marine Corps
(Code MPI-20)
Washington, DC 20380

Civilian Agencies

1 Dr. Patricia A. Butler
NIE-BRN Bldg., Stop #7
1200 19th St. NW
Washington, DC 20208

1 Dr. Susan Chipman
Learning & Development
NIE
1200 19th St. NW
Washington, DC 20208

1 Dr. Arthur Melmed
724 Brown
US Department of Education
Washington, DC 20208

1 Dr. Andrew R. Molnar
Sci. Ed. Dev. & Res.
NSF
Washington, DC 20550

1 Dr. Vern W. Urry
Personnel R&D Center
Office of Personn. Mngmnt.
1900 E St. NW
Washington, DC 20415

1 Thomas A. Warm
Coast Guard Inst.
P.O. Substation 18
Oklahoma City, OK 73169

1 Frank Withrow
US office of Ed.
400 Maryland Ave. SW
Washington, DC 20202

1 Dr. Joseph L. Young, Dir.
Memory & Cognitive Processes
NSF
Washington, DC 20550

Other Department of Defense

12 Defense Technical Information Center
Cameron Station, Bldg 5
Alexandria, VA 22314
Attn:TC

1 Dr. Craig I. Fields
Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

1 Dr. William Graham
Testing Directorate
MEPCOM/MEPCT-P
Ft. Sheridan, IL 60037

1 Jerry Lehnus
HQ MEPCOM
Attn. MEPCT-P
Fort Sheridan, IL 60037

1 Military Assistant for
Training and Personnel Tech.
Office of the Under Secretary
of Defense for Res. & Eng.
Room 3D129, The Pentagon
Washington, DC 20301

1 Dr. Wayne Sellman
Office of the Astnt. Sec.
of Defense (MRA & L)
Room 2B269, The Pentagon
Washington, DC 20301

1 Major Jack Thorpe
DARPA
1400 Wilson Blvd.
Arlington, VA 22209

Private Sector

1 Dr. James Algina
University of Florida
Gainsville, FL 32611

1 Dr. John R. Anderson
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213

1 Dr. Thomas Anderson
CSR
174 Children's Res. Lab.
51 Gerty Drive
Champaign, IL 61820

1 Dr. Patricia Baggett
Dept. of Psych.
University of Colorado
Boulder, CO 80309

1 Mr. Avron Barr
Department of Computer Science
Stanford University
Stanford, CA 94305

1 Dr. Issac Bejar
Educational Testing Serv.
Princeton, NJ 08450

1 Dr. Menucha Birenbaum
School of Ed.
Tel Aviv University
Ramat Aviv - Box 39040
Tel Aviv 69978
ISRAEL

1 Dr. Werner Birke
DezWPs im Streitkraefteamt
Postfach 20 50 03
D-5300 Bonn 2
WEST GERMANY

1 Dr. Darrel Bock
Dept. of Ed.
University of Chicago
Chicago, IL 60637

1 Dr. Walter Bogan
4615 N. Park Ave, no. 1611
Chevy Chase, MD 20015

1 Dr. Robert Brennan
American College Testing Programs
P.O. Box 168
Iowa City, IA 52240

1 Dr. John S. Brown
XEROX Palo Alto Res. Cnt.
3333 Coyote Rd.
Palo Alto, CA 94304

1 Dr. Leigh Burstein
Dept. of Education
University of California
Los Angeles, CA 90024

1 Dr. John B. Carroll
Psychometric Lab
Univ. of N. Carolina
Davie Hall 013A
Chapel Hill, NC 27514

1 Dr. William Chase
Dept. of Psych.
Carnegie Mellon University
Pittsburgh, PA 15213

1 Dr. William Clancey
Dept. of Computer Sci.
Stanford University
Stanford, CA 94305

1 Dr. Deborah Coates
Catholic University
620 Michigan Ave. NE
Washington, DC 20064

1 Dr. Norman Cliff
Dept. of Psychology
U. of S. California
University Park
Los Angeles, CA 90007

1 Dr. Allan M. Collins
Bolt Beranek & Newman
50 Moulton St.
Cambridge, MA 02138

1 Dr. Lynn A. Cooper
LRDC
University of Pittsburgh
3939 O'Hara St.
Pittsburgh, PA 15213

1 Dr. Hans Crombag
Education Research Cntr.
University of Leyden
Boerhaavelaan 2
2334 EN Leyden
The NETHERLANDS

1 Dr. Dattpradad Divgi
Syracuse University
Deparment of Psychology
Syracuse, NY 33210

1 Dr. Susan Embretson-Whitely
Psychology Department
University of Kansas
Lawrence, KS 66045

1 ERIC Facility-Acquisitions
4833 Rugby Ave.
Bethesda, MD 20014

1 Dr. Benjamin Fairbank
McFann-Gray & Associates, Inc.
5825 Callaghan Rd.
Suite 225
San Antonio, TX 78228

1 Dr. Meredith Crawford
American Psych. Association
1200 17th St., NW
Washington, DC 02138

1 Dr. Lee Cronbach
Dept. of Education
Stanford University
Stanford, CA 94305

1 Dr. Evelyn Doody
Dept. of Psych
U of Oklahoma
529-D Stinson
Norman, OK 73069

1 Dr. Fritz Drasgow
Department of Psychology
University of Illinois
603 E. Daniels St.
Urbana, IL 61820

1 Dr. Leonard Feldt
Lindquist Center for Measmnt.
University of Iowa
Iowa City, IA 52242

1 Dr. Richard Ferguson
The Am. College Testing Prog.
P.O. Box 168
Iowa City, IA 52240

1 Mr. Wallace Feurzeig
Bolt Beranek & Newman, Inc.
50 Moulton St.
Cambridge, MA 02138

1 Dr. Victor Fields
Dept. of Psychology
Montgomery College
Rockville, MD 20850

1 Dr. Gerhard Fischer
Liebiggasse 5/3
A 1010 Vienna
AUSTRIA

1 Dr. Donald Fitzgerald
Univeraity of New England
Armidale, N. S. Wales 2351
AUSTRALIA

1 Dr. Dexter Fletcher
WICAT Research Inst.
1875 S. State St.
Orem, UT 22333

1 Dr. John Frederiksen
Bolt Beranek & Newman
50 Moulton St.
Cambridge, MA 02138

1 Dr. Paul Games
403D Carpenter
University Park, PA 16802

1 Dr. Janice Gifford
University of Massachusetts
School of Education
Amherst, MA 01002

1 Dr. Robert Glaser
LRDC
University of Pittsburgh
3939 O'Hara St.
Pittsburgh, PA 15213

1 Dr. Bert Green
John Hopkins University
Dept. of Psychology
Charles & 34th St.
Baltimare, MD 21218

1 Dr. James Greeno
LRDC
3939 O'Hara St.
Pittsburgh, PA 15213

1 Dr. Ron Hambleton
School of Education
University of Massachusetts
Amherst, MA 01002

1 Dr. Delwyn Harnisch
ICBD
University of Illinois
51 Gerty Drive
Champaign, IL 61801

1 Dr. Kristina Hooper
Clark Kerr Hall
University of Calif.
Santa Cruz, CA 95060

1 Dr. Paul Holtzman
Decision Systems
MFI
100 S. Wacker Drive
Chicago, IL 60606

1 Dr. Lloyd Humphreys
421 Psychology
University of Illinois
Champaign, IL 61820

1 Prof. Raimo Konttinen or
Library
Institute for Ed Research
University of Jyvaskyla
40100 Jyvaskyla
FINLAND

1 Library
HumRRO/Western Division
27857 Berwick Drive
Carmel, CA 93921

1 Dr. Steven Hunka
Dept. of Education
University of Alberta
Edmonton, Alberta
CANADA

1 Dr. Earl Hunt
Dept. of Psychology
University of Washington
Seattle, WA 98105

1 Dr. Jack Hunter
2122 Coolidge St.
Lansing, MI 48906

1 Dr. Huynh Huynh
College of Education
University of South Carolina
Columbia, SC 29208

1 Dr. Douglas H. Jones
Room T-225/21-T
Educational Testing Service
Princeton, NJ 08541

1 Professor John A. Keats
University of Newcastle
AUSTRALIA 2308

1 Dr. William Koch
University of Texas-Austin
Measurement and Evaluation Cntr.
Austin, TX 78703

1 Jeff Kelety
Dept. of Instr. Tech.
University of S. Calif.
Los Angeles, CA 92007

1 Dr. Walter Kintsch
Dept. of Psych.
University of Colorado
Boulder, CO 80302

1 Dr. David Kieras
Dept. of Psych.
University of Arizona
Tucson, AZ 85721

1 Dr. Stephan Kosslyn
Harvard University
Dpt. of Psych.
33 Kirkland St.
Cambridge, MA 02138

1 Mr. Marlin Kroger
1117 Via Goleta
Palos Verdes Estates, CA 90274

1 Dr. Marcy Lansman
Dpt. of Psych. NI 25
Univ. of Washington
Seattle, WA 98195

1 Dr. Jill Larkin
Dpt. of Psych.
Carnegie Mellon Univ.
Pittsburgh, PA 15213

1 Dr. Alan Lesgold
LRDC
Univ. of Pittsburgh
Pittsburgh, PA 15260

1 Dr. Michael Levine
Dept. of Ed Psych
210 Education Bldg.
University of Illinois
Champaign, IL 61801

1 Dr. Charles Lewis
Faculteit Sociale Wetenschappen
Rijksuniversiteit Groningen
Oude Boteringestraat 23
9712GC Groningen
NETHERLANDS

1 Dr. Robert Linn
210 Education
University of Illinois
Urbana, IL 61801

1 Mr. Phillip Livingston
Systems and Applied Sci.
6811 Kenilworth Ave.
Riverdale, MD 20840

1 Dr. Robert Lockman
Center for Naval Analysis
200 N. Beauregard St.
Alexandria, VA 22311

1 Bob Loo, Ph.D.
Department of Psychology
The University of Calgary
2920 - 24th Ave. NW
Calgary, Alberta
CANADA T2N 1N4

1 Dr. Frederick M. Lord
Educational Testing Ser.
Princeton, NJ 08540

1 Dr. James Lumsden
Dpt. of Psychology
University of Western Australia
Nedlands W.A. 6009
AUSTRALIA

1 Dr. Drew Malizio
American Counc. on Ed.
No. 1 Pont Circle, #20
Washington, DC 20036

1 Dr. Gary Marco
Stop 31-E
Educational Testing Service
Princeton, NJ 08540

1 Dr. Scott Maxwell
Dpt. of Psych.
Univ. of Houston
Houston, TX 77004

1 Dr. David McArthur
CSE 145 Moor Hall
UCLA
Los Angeles, CA 90024

1 Dr. Samuel T. Mayo
Loyola U. of Chicago
820 N. Michigan Av.
Chicago, IL 60611

1 Mr. Robert McKinley
American College Testing
P.O. Box 168
Iowa City, IA 52243

1 Dr. Erik McWilliams
Science Ed. Dev. & Res.
National Science Foundation
Washington, DC 20550

1 Dr. Peter Mich
Ed Psych
Enderis Hall 719
University of Wisconsin
P.O. Box 413
Milwaukee, WE 53201

1 Dr. Robert Mislevy
711 Illinois St.
Geneva, IL 60134

1 Dr. Allen Munro
Behvr. Tech. Lab.
1845 Elena Ave. 4th floor
Redondo Beach, CA 90277

1 Dr. Alan Nicewander
University of Oklahoma
Department of Psychology
Oklahoma City, OK 73069

1 Dr. Anthony J. Nitko
School of Ed.
Division of Ed. Studies
University of Pittsburgh
5C03 Forbes Quandrangle
Pittsburgh, PA 15260

1 Dr. Donald A. Norman
Dpt. of Psych. C-009
Univ. of Calif.
La Jolla, CA 92093

1 Dr. Melvin Novick
356 Lindquist Cntr for Measur.
University of Iowa
Iowa City, IA 52242

1 Dr. James Olson
WICAT, Inc.
1875 S. State St.
Orem, UT 84057

1 Dr. Jesse Orlansky
Inst. for Defense Analyses
400 Army Navy Drive
Arlington, VA 22202

1 Dr. Seymour A. Papert
MIT
Artific. Intelli. Lab.
545 Technology Square
Cambridge, MA 02139

1 Wayne M. Patience
American Council on Education
GED Testing Service, suite 20
One Dupont Circle, NW
Washington, DC 20036

1 Dr. James A. Paulson
Portland State University
P.O. Box 751
Portland, OR 97207

1 Dr. James Pellegrino
Univ. of Calif.
Dpt. of Psych.
Santa Barbara, CA 93106

1 Dr. Martha Polson
Dpt. of Psych.
Campus Box 346
University of Colorado
Boulder, CO 80309

1 Dr. Peter Posner
Dpt. of Psych.
Univ. of Oregon
Eugene, OR 97403

1 Dr. Peter Polson
Dpt. of Psych.
University of Colorado
Boulder, CO 80309

1 Dr. Diane M. Ramsey-Klee
R-K Res. & System Design
3947 Ridgemont Dr.
Malibu, CA 90265

1 Minrat M. L. Rauch
P II 4
Bundesministerium der
Verteidigung
Postfach 1328
D-53 Bonn 1
GERMANY

1 Dr. Mark D. Reckase
Ed Psych Dept.
University of Missouri
4 Hill Hall
Columbia, MO 65211

1 Dr. Lauren Resnick
LRDC
University of Pittsburgh
3939 O'Hara St.
Pittsburgh, PA 15213

1 Dr. Thomas Reynolds
University of Texas
Marketing Department
P.O. Box 688
Richardson, TX 75080

1 Dr. Andrew M. Rose
American Inst. for Res.
1055 Thomas Jefferson St. NW
Washington, DC 20007

1 Dr. Leonard L. Rosenbuam
Dept. of Psychology
Montgomery College
Rockville, MD 20850

1 Dr. Ernst Z. Rothkopf
Bell Laboratories
600 Mountain Ave.
Murry Hill, NJ 07974

1 Dr. Lawrence Rudner
403 Elm Ave.
Takoma Park, MD 20012

1 Dr. David Rumelhart
Cntr. for Human Info.
Univ. of Calif.
La Jolla, CA 92093

1 Dr. J. Ryan
Dept. of Ed.
University of S. Carolina
Columbia, SC 29208

1 Dr. Fumiko Samejima
Dept. of Psychology
U. of Tennessee
Knoxville, TN 37916

1 Dr. Walter Schneider
Psychology Deparment
603 E. Daniel
Champaign, IL 61820

1 Dr. Alan Schoenfeld
Dpt. of Mathematics
Hamilton College
Clinton, NY 13323

1 Lowell Schoer
Psychological & Quantitative Foun.
College of Education
University of Iowa
Iowa City, IA 52242

1 Dr. Robert J. Seidel
Instr. Tech. Group
HUMMRRO
300 N. Washington St.
Alexandria, VA 22314

1 Dr. John Serber
University of Wisconsin
Dept. of Ed Psych
Milwaukee, WI 53201

1 Dr. Shigemasu
University of Tohoku
Dept. of Ed Psych
Kawauchi, Sendai 980
JAPAN

1 Dr. Edwin Shirkey
Dept. of Psychology
University of Centl Florida
Orlando, FL 32816

1 Dr. William Sims
Center for Naval Analysis
200 N. Beauregard St.
Alexandria, VA 22311

1 Dr. Wallace Sinaiko
Program Director
Manpower Res. & Advi.
Smithsonian Institution
801 N. Pitt St.
Alexandria, VA 22314

1 Dr. Richard Snow
School of Ed.
Stanford University
Stanford, CA 94305

1 Dr. Kathryn T. Spoehr
Psychology Dpt.
Brown Univerity
Providence, RI 02912

1 Dr. Robert Sternberg
Dept. of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

1 Dr. Peter Stoloff
Center for Naval Analysis
200 N. Beauregard St.
Alexandria, VA 23311

1 Dr. William Stout
University of Illinis
Dpt of Mathematics
Urbana, IL 61801

1 Dr. Albert Stevens
Bolt Beranek & Newman, Inc.
50 Moulton St.
Cambridge, MA 02138

1 Dr. David E. Stone
Hazeltine Corp.
7680 Old Springhouse Rd.
McLean, VA 22102

1 Dr. Patrick Suppes
Inst. for Math. Studies
in Soc. Sci.
Stanford University
Stanford, CA 94305

1 Dr. Hariharan Swaminathan
Lab. of Psychom. & Evl. Res.
School of Ed.
University of Massachusetts
Amherst, MA 01003

1 Dr. Brad Sympson
Code P310
Navy Personnel R&D Cntr
San Diego, CA 92152

1 Dr. David Thissen
Dept. of Psychology
U. of Kansas
Lawrence, KS 66044

1 Dr. Perry Thorndyke
The Rand Corp.
1700 Main St.
Santa Monica, CA 90406

1 Dr. Douglas Towne
University of S. California
Behav. Tech. Labs
1845 S. Elena Ave.
Redondo Beach, CA 90277

1 Dr. Robert Tsutakawa
Dept. of Statistics
University of Missouri
Columbia, MO 65201

1 Dr. V. Uppuluri
Union Carbide Corp.
Nuclear Division
P.O. Box Y
Oak Ridge, TN 37830

1 Dr. David Vale
Assessment Systems Corp.
2233 University Ave.
Suite 310
St. Paul, MN 55114

1 Dr. Kurt VanLehn
Xerox PARC
3333 Coyote Hill Rd.
Palo Alto, CA 94304

1 Dr. Howard Wainer
Division of Psychological Studies
Ed. Testing Service
Princeton, NJ 08540

1 Dr. Michael Waller
Dpt. of Educational Psych
University of Wisconsin
Milwaukee, WI 53201

1 Dr. Brian Waters
HumRRO
300 N. Washington St.
Alexandria, VA 22314

1 Dr. David Weiss
N660 Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

1 Dr. Keith Wescourt
Perceptronics, Inc.
545 Middlefield Rd. Suite 140
Menlo Park, CA 94205

1 P.O. White
Dept. of Psychology
Institute of Psychiatry
DeCrespigry Park
London SE5 8AF
ENGLAND

1 Dr. Rand R. Wilcox
University of S. California
Dpt. of Psychology
Los Angeles, CA 90007

1 Wolfgang Wildgrube
Streitdraefteamt
Box 20 50 03
D-5300 Bonn 2
WEST GERMANY

1 Dr. Steven Wise
Dept. of Guid. & Ed Psych
S. Illinis University
Carbondale, IL 62901

1 Dr. Wendy Yen
CTB/McGraw Hill
Del Monte Research Park
Monterey, CA 93940

END

FILMED

5-84

DTIC